

**ANALYTICAL METHOD FOR TURBIDITY MEASUREMENT
METHOD 180.1**

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Analytical Method for Turbidity Measurement

Method 180.1

1. Scope and Application

- 1.1** This method is applicable to drinking water samples in the range of turbidity from 0 to 40 nephelometric units (NTU). Higher values may be obtained with dilution of the sample. A method detection limit of 0.100 NTUs is recommended for this procedure.

NOTE: NTUs are considered comparable to the previously reported Formazin Turbidity Units (FTU).

- 1.2** This method covers the determination of turbidity in drinking, ground, surface, and saline waters, domestic and industrial wastes.

2. Summary of Method

- 2.1** The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of the scattered light, the higher the turbidity. Readings, in NTUs, are made in a nephelometer designed according to specifications outlined in "APPARATUS." A standard suspension of Formazin, prepared under closely defined conditions, is used to calibrate the instrument.

2.1.1 Formazin polymer is used as the turbidity reference suspension for water because it is more reproducible than other types of standards previously used for turbidity standards.

2.1.2 A commercially available polymer primary standard is also approved for use for the National Interim Primary Drinking Water Regulations. This standard is identified as AMCO-AEPA-1, available from Advanced Polymer Systems.

3. Sample Handling and Preservation

- 3.1** Collect each sample in a soft or hard plastic, or soft or hard glass container. Immediately refrigerate or ice the sample to 4°C and analyze within 48 hours.

4. Conditions Affecting Turbidity Reading

- 4.1** The presence of floating debris and coarse sediments, which settle out rapidly, will give low readings. Finely divided air bubbles will affect the results in a positive manner.
- 4.2** The presence of color, that is the color of water which is due to dissolved substances which absorb light, will cause turbidities to be low, although this effect is generally not significant.

- 4.3** Light absorbing materials such as activated carbon in significant concentrations can cause low readings.

5. Apparatus

- 5.1** The turbidimeter shall consist of a nephelometer, with light source for illuminating the sample, and one or more photo-electric detectors with a readout device to indicate the intensity of light scattered at right angles to the path of the incident light. The turbidimeter should be designed so that little stray light reaches the detector in the absence of turbidity and should be free from significant drift after a short warm-up period.
- 5.2** Differences in physical design of turbidimeters will cause differences in measured values for turbidity, even though the same suspension is used for calibration. To minimize such differences, the following design criteria should be observed:
- 5.2.1** Light source: Tungsten lamp operated at a color temperature between 2200-3000°K.
- 5.2.2** Distance traversed by incident light and scattered light within the sample tube: Total not to exceed 10 cm.
- 5.2.3** Detector: Centered at 90° to the incident light path and not to exceed $\pm 30^\circ$ from 90°. The detector, and filter system if used, shall have a spectral peak response between 400 nm and 600 nm.
- 5.3** The sensitivity of the instrument should permit detection of a turbidity difference of 0.02 NTU or less in waters having turbidities less than 1 unit. The instrument should measure from 0-40 units turbidity. Several ranges may be necessary to obtain both adequate coverage and sufficient sensitivity for low turbidities.
- 5.4** The sample tubes to be used with the available instrument must be of clear, colorless optical glass. They should be kept scrupulously clean, both inside and out, and discarded when they become scratched or etched. They must not be handled at all where the light strikes them, but should be provided with sufficient extra length, or with a protective case, so that they may be handled. Tubes should be checked, indexed and read at the orientation that produces the lowest background blank value.

6. Reagents

- 6.1** Reagent water, turbidity-free: Pass deionized distilled water through a 0.45: pore size membrane filter, if such filtered water shows a lower turbidity than unfiltered distilled water.
- 6.2** Stock standard suspension (Formazin):
- 6.2.1** Dissolve 1.00 g hydrazine sulfate, $(\text{NH}_2)_2\text{H}_2\text{SO}_4$, (CASRN 10034-93-2) in reagent water and dilute to 100 mL in a volumetric flask. **CAUTION** -- carcinogen.

- 6.2.2** Dissolve 10.00 g hexamethylenetetramine (CASRN 100-97-0) in reagent water and dilute to 100 mL in a volumetric flask. In a 100 mL volumetric flask, mix 5.0 mL of each solution (Sections 6.2.1 and 6.2.2). Allow to stand 24 hours at $25 \pm 3^\circ\text{C}$, then dilute to the mark with reagent water.
- 6.3** Primary calibration standards: Mix and dilute 10.00 mL of stock standard suspension (Section 7.2) to 100 mL with reagent water. The turbidity of this suspension is defined as 40 NTU. For other values, mix and dilute portions of this suspension as required.
- 6.3.1** A new stock standard suspension (Section 6.2) should be prepared each month. Primary calibration standards (Section 6.3) should be prepared daily by dilution of the stock standard suspension.
- 6.4** Formazin in commercially prepared primary concentrated stock standard suspension (SSS) may be diluted and used as required. Dilute turbidity standards should be prepared daily.
- 6.5** AMCO-AEPA-1 Styrene Divinylbenzene polymer primary standards are available for specific instruments and require no preparation or dilution prior to use.
- 6.6** Secondary standards may be acceptable as a daily calibration check, but must be monitored on a routine basis for deterioration and replaced as required.

7. Procedure

- 7.1** Turbidimeter calibration: The manufacturer's operating instructions should be followed. Measure standards on the turbidimeter covering the range of interest. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of the calibration scales. At least one standard should be run in each instrument range to be used. Some instruments permit adjustments of sensitivity so that scale values will correspond to turbidities. Solid standards, such as those made of lucite blocks, should never be used due to potential calibration changes caused by surface scratches. If a pre-calibrated scale is not supplied, then calibration curves should be prepared for each range of the instrument.
- 7.2** Turbidities less than 40 units: If possible, allow samples to come to room temperature before analysis. Shake the sample to thoroughly disperse the solids. Wait until air bubbles disappear. Then pour the sample into the turbidimeter tube. Read the turbidity directly from the instrument scale or from the appropriate calibration curve.
- 7.3** Turbidities exceeding 40 units: Dilute the sample with one of more volumes of turbidity-free water until the turbidity falls below 40 units. The turbidity of the original sample is then computed from the turbidity of the diluted sample and the dilution factor. For example, if 5 volumes of turbidity-free water were added to 1 volume of sample, and the diluted sample showed a turbidity of 30 units, then the turbidity of the original sample was 180 units.

8. Calculations

8.1 Nephelometric turbidity units (NTU)

$$= \frac{A \times (B + C)}{C} \quad \text{where:} \quad \begin{array}{l} A = \text{NTU found in diluted sample} \\ B = \text{volume of dilution water, in mL} \\ C = \text{sample volume taken for dilution, in mL} \end{array}$$

8.2 Report results as follows:

NTU	Record to Nearest
0.0 - 1.0	0.05
1 - 10	0.1
10 - 40	1
40 - 100	5
100 - 400	10
400 - 1000	50
> 1000	100

9. Precision and Accuracy

9.1 In a single laboratory (EMSL-Cincinnati), using surface water samples at levels of 26, 41, 75, and 180 NTU, the standard deviations were ± 0.60 , ± 0.94 , ± 1.2 , and ± 4.7 units, respectively.

9.2 The interlaboratory precision and accuracy data in Table 1 were developed using a reagent water matrix. Values are in NTU.

10. Safety

10.1 The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable.

10.2 Each laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of Material Safety Data Sheets (MSDS) should be made available to all personnel involved in the chemical analysis. The preparation of a formal safety plan is also advisable.

10.3 Hydrazine Sulfate (Section 6.2.1) is a carcinogen. It is highly toxic and may be fatal if inhaled, swallowed, or absorbed through the skin. Formazin can contain residual hydrazine sulfate. Proper protection should be employed.

11. Quality Assurance

- 11.1** Each laboratory using this method in regulated environmental monitoring is required to operate a formal quality assurance/control program. The minimum initial requirements of this program consist of the demonstration of the laboratory's capability with this method. On a continuing basis, the laboratory should check its performance (accuracy and precision) by analyzing reagent blanks and check standards, fortified blanks, and/or fortified samples, preferably at a minimum frequency of 10% of the total samples analyzed by the method. The laboratory should maintain the performance records that define the quality of the data generated with the method.

12. Pollution Prevention

- 12.1** Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.
- 12.2** The quantity of chemicals purchased should be based on expected usage during its shelf life and disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.
- 12.3** For information about pollution prevention that may be applicable to laboratories and research institutions, consult "Less is Better: Laboratory Chemical Management for Waste Reduction," available from the American Chemical Society's Department of Government Regulations and Science Policy, 1155 16th Street N.W., Washington D.C. 20036, (202)872-4477.

13. Waste Management

- 13.1** The U.S. Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes should be characterized and disposed of in an acceptable manner. The Agency urges laboratories to protect the air, water and land by minimizing and controlling all releases from hoods, and bench operations, complying with the letter and spirit of any waste discharge permit and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management consult the "Waste Management Manual for Laboratory Personnel," available from the American Chemical Society at the address listed in Section 12.3.

Bibliography

1. Annual Book of ASTM Standards, Volume 11.01 Water (1), Standard D1889-88A, p. 359, (1993).
2. Standard Methods for the Examination of Water and Wastewater, 18th Edition, pp. 2-9, Method 2130B, (1992).
3. Standard Methods for the Certification of Laboratories Analyzing Drinking Water: Criteria and Procedures, Quality Assurance, EPA/570/9-90/008, April, 1990.

14.0 Tables, Diagrams, Flowcharts and Validation Data

TABLE 1. INTERLABORATORY PRECISION AND ACCURACY DATA

Number of Values Reported	True Value (T)	Mean (X)	Residual for X	Standard Deviation (S)	Residual for S
373	0.450	0.4864	0.0027	0.1071	-0.0078
374	0.600	0.6026	-0.0244	0.1048	-0.0211
289	0.65	0.6931	0.0183	0.1301	0.0005
482	0.910	0.9244	0.0013	0.2512	0.1024
484	0.910	0.9919	0.0688	0.1486	-0.0002
489	1.00	0.9405	-0.0686	0.1318	-0.0236
640	1.36	1.3456	-0.0074	0.1894	0.0075
487	3.40	3.2616	-0.0401	0.3219	-0.0103
288	4.8	4.5684	-0.0706	0.3776	-0.0577
714	5.60	5.6984	0.2952	0.4411	-0.0531
641	5.95	5.6026	-0.1350	0.4122	-0.1078

REGRESSIONS: $X = 0.955T + 0.54$, $S = 0.074T + 0.082$